

What is claimed is:

1. A method of selectively ablating material, the method comprising:
  - providing a substrate underlying regions of at least two different materials;
  - providing laser pulses having tunable wavelengths;
  - tuning the laser pulses to a wavelength corresponding to a desired material characteristic of at least one of the at least two materials;
  - shining the tuned laser pulses onto the regions of at least two materials until a portion of one of the at least two materials is ablated from the substrate.
2. The method of claim 1, wherein said tuning includes tuning the wavelength of the laser pulses to approximate a peak absorption wavelength of one of the at least two materials.
3. The method of claim 1, wherein said tuning includes tuning the wavelength of the laser pulses to approximate a peak reflection wavelength of one of the at least two materials.
4. The method of claim 1, wherein said tuning includes tuning the wavelength of the laser pulses to approximate a peak reflection wavelength of the substrate.
5. The method of claim 1, wherein said shining includes shining the laser pulses to remove the portion of the at least two materials without damaging the underlying substrate.

6. The method of claim 1, further comprising controlling a pulse width of the laser pulses.

7. The method of claim 1, further comprising controlling one or more of a pulse duration and a wavelength of the laser pulses so as to selectively ablate an undesired one of the at least two different materials without damaging the substrate or any material adjacent to the undesired material.

8. The method of claim 1, further comprising controlling both a pulse duration and a wavelength of the laser pulses so as to selectively ablate an undesired one of the at least two different materials without damaging the substrate or any material adjacent to the undesired material.

9. A method of producing an essentially defect-free photomask mask for semiconductor applications, the method comprising:

providing a substrate including a surface having an absorbing layer patterned thereon as a mask to yield a circuit when transferred to a resist coated wafer;  
inspecting the mask and detecting a defect on the mask in a defect region; and  
directing energy on said defect region and removing a substantial portion of said defect.

10. The method of claim 9, wherein said mask comprises a reflective substrate.

11. The method of claim 9, wherein said mask comprises a reflective metal.
12. The method of claim 9, wherein said mask comprises a reflective substrate having a stack of dielectric layers arranged to be reflective at a specified wavelength of light.
13. The method of claim 9, wherein said mask comprises a reflective substrate having a single layer of material reflective in a visible region of light.
14. The method of claim 9, wherein said mask comprises a reflective substrate having multiple layers of material reflective in a visible region of light.
15. The method of claim 9, wherein said directing energy includes directing laser pulses on the defect region.
16. A method of repairing a defect on a mask, the method comprising:
  - providing a reflective substrate comprising the mask which includes a first region and a second region,
  - wherein a light absorbing first material covers said first region and said second region is free of the light absorbing material;
  - inspecting the mask and detecting an essentially opaque defect on the mask in a defect region;
  - shining a plurality of laser pulses on said defect region to ablate said defect after selecting a pulse duration of said laser pulses; and

removing said defect without damaging said reflective substrate underlying said defect.

17. The method of claim 16, further comprising providing an absorbing region adjacent said defect region,

said absorbing region having an edge with an edge placement tolerance,

wherein said removing leaves said edge of said absorbing region within said edge placement tolerance.

18. The method of claim 17, wherein said removing leaves said edge within a placement tolerance of 10% or less.

19. The method of claim 16, wherein said removing removes said defect without splattering any defect material on said substrate.

20. The method of claim 16, wherein said removing removes said defect without any pitting of said substrate.

21. The method of claim 16, wherein said removing removes said defect while maintaining at least 95% of an original reflectivity of the substrate in the defect region of the substrate.

22. The method of claim 16, wherein said removing removes said defect while maintaining at least 98% of an original reflectivity of the substrate in the defect region of the substrate.

23. A method of removing material from a reflective substrate, the method comprising:

providing a reflective substrate having a region with a non-reflective or absorbing material thereon;

shining a plurality of laser pulses on said non-reflective or absorbing region to remove said material without damaging said reflective substrate underlying said material.

24. The method of claim 23, wherein said reflective substrate is a mask.

25. The method of claim 23, wherein said material is a defect in a mask.

26. The method of claim 23, wherein said material comprises chrome or molybdenum.

27. The method of claim 23, wherein a reflectivity under the removed material is within 2% of a reflectivity of the reflective substrate in a region in which no material has been removed.

28. The method of claim 23, wherein a reflectivity under the removed material is within 5% of a reflectivity of the reflective substrate in a region in which no material has been removed.

29. The method of any one of claims 1, 15, 16, and 23, further comprising controlling a pulse width of the laser pulses to have a pulse duration of less than 10 picoseconds.

30. The method of any one of claims 1, 15, 16, and 23, further comprising controlling a pulse width of the laser pulses to have a pulse duration of less than 1 picosecond.

31. The method of any one of claims 1, 15, 16, and 23, further comprising controlling a pulse width of the laser pulses to have a pulse duration of less than 200 femtoseconds.

32. The method of any one of claims 1, 15, 16, and 23, further comprising controlling a pulse width of the laser pulses to have a pulse duration of less than 50 femtoseconds.

33. The method of any one of claims 4, 9, 13, 14, 16, and 23, wherein said substrate is reflective in a region of light from 1 micron to 400 nm.

34. The method of any one of claims 4, 9, 13, 14, 16, and 23, wherein said substrate is reflective in a region of light from 100 nm to 200 nm.

35. The method of any one of claims 4, 9, 13, 14, 16, and 23, wherein said substrate is reflective in a region of light from 200 nm to 400 nm.

36. The method of any one of claims 4, 9, 13, 14, 16, and 23, wherein said substrate is reflective in a region of light from 10 nm to 100 nm.

37. The method of any one of claims 4, 9, 13, 14, 16, and 23, wherein said substrate is reflective in a region of light from 1 nm to 10 nm.

38. The method of any one of claims 1, 15, 16, and 23, further comprising tuning a wavelength of the laser pulses to be in a region from 157 nm to 1 micron.

39. The method of any one of claims 1, 15, 16, and 23, further comprising tuning a wavelength of the laser pulses to be in a region from 13 nm to 157 nm.

40. The method of any one of claims 1, 15, 16, and 23, further comprising tuning a wavelength of the laser pulses to be less than 13 nm.

41. The method of any one of claims 9 and 16, further comprising ablating said defect layer by layer.

42. The method of any one of claims 9 and 16, further comprising focusing said laser pulses above a defect surface in a manner which minimizes any damage to an underlying reflective layer.

43. An apparatus for repairing a defect on a reflective photomask, the apparatus comprising:

a laser capable of providing femtosecond pulse width laser light;

a harmonic conversion cell optically coupled to the laser;

a filter for blocking a fundamental wavelength and passing a selected harmonic of the laser light;

an objective lens arrangement configured to provide the selected harmonic of the laser light onto the reflective photomask; and

a control unit operatively connected to the laser to control an ablation of the defect on the reflective photomask.

44. The apparatus of claim 43, wherein the selected harmonic comprises 13 nm EUV laser light.

45. The apparatus of claim 43, wherein the selected harmonic comprises 157 nm laser light.

46. The apparatus of claim 43, wherein the selected harmonic comprises 193 nm laser light.

47. The apparatus of claim 43, wherein the filter comprises a rare gas cell.
48. The apparatus of claim 43, wherein the control unit controls an energy level of the laser light provided onto the reflective photomask.